Journal of Prevention, Diagnosis and Management of Human Diseases
Vol: 06, No. 02, July-Dec 2026
ISSN: 2799-1202, DOI: 10.55529/jpdmhd.62.18.32

Research Paper

Sleep duration, sleep complaints and positive depression screening in US adults: dose–response and population attributable fractions from NHANES 2009–2012

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Article Info

Article History:
Received: 19 March 2026
Revised: 28 May 2026
Accepted: 05 June 2026
Published: 22 July 2026

Keywords:
Depression
Sleep duration
Insomnia
Patient Health Questionnaire
Population attributable fraction

ABSTRACT

Background: Sleep problems are common, modifiable and increasingly regarded as targets for preventing depression. Their association with depressive symptoms and the share of positive depression screens potentially attributable to them in the general US population are incompletely characterised.
Objective: To examine how usual sleep duration and clinically reported sleep trouble relate to a positive depression screen in US adults, and to estimate the proportion of positive screens potentially attributable to them.
Methods: Cross-sectional analysis of 9,832 non-pregnant adults aged ≥20 years from the National Health and Nutrition Examination Survey (NHANES) 2009–2012 (9,711 with complete covariates in regression models). A positive screen was defined as a Patient Health Questionnaire-2 (PHQ-2) score ≥3. Survey-weighted logistic regression with design-based variance was used to estimate adjusted odds ratios (ORs), predictive margins and population attributable fractions (PAFs).
Results: Overall, 6.8% (95% CI 6.0–7.7%) of adults screened positive; 36.7% slept ≤6 hours and 26.8% had told a health professional about trouble sleeping. Positive screens followed a U-shaped pattern, from 3.9% at 7 hours to 14.6% at ≤5 hours and 11.3% at ≥9 hours. After full adjustment, sleeping ≤5 hours (OR 2.10, 1.54–2.86), sleeping ≥9 hours (OR 2.26, 1.48–3.45) and reported sleep trouble (OR 2.94, 2.35–3.68) were independently associated with a positive screen. Adults with both long sleep and sleep trouble had an OR of 10.5 (5.7–19.4). Under causal assumptions, short sleep and sleep trouble together accounted for 43.6% (36.8–50.3%) of positive screens.
Conclusions: Sleep duration and sleep complaints are strongly and independently associated with depressive symptoms. Routine sleep assessment could help identify adults at elevated likelihood of depressive symptoms, complementing universal depression screening. Sleep-focused interventions merit evaluation as a preventive strategy.

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1. INTRODUCTION

Depressive disorders are the largest contributor to the global burden of mental disorders [1] and affect an estimated 322 million people worldwide [2]. In the United States, 8.1% of adults aged ≥20 years had depression in a given two-week period in 2013–2016 [3], and the 12-month prevalence of major depressive disorder is about 10% [4]. The US Preventive Services Task Force recommends screening all adults for depression, commonly with the two-item and nine-item Patient Health Questionnaires (PHQ-2, PHQ-9) [5], [6], [7], [8].

Sleep and depression are closely linked. Disturbed sleep is a core symptom of depression, but it also precedes it: in meta-analyses of prospective studies, insomnia roughly doubled the risk of subsequent depression [9], [10], and both short and long sleep durations were associated with incident depression [11]. Proposed mechanisms include hyperarousal, dysregulation of the hypothalamic–pituitary–adrenal axis, inflammation and circadian disruption [12], [13]. Importantly, the relationship appears modifiable: cognitive behavioural therapy for insomnia (CBT-I) reduced depressive symptoms in a large digital trial [14] and halved the incidence of major depression in older adults with insomnia [15].

Insufficient sleep is common. Consensus statements recommend at least 7 hours per night for adults [16], [17], yet about one-third of US adults report less [18], with marked socioeconomic and racial disparities [19], [20]. Short sleep has been linked to a range of adverse outcomes [21]. A recent analysis of NHANES 2009–2016 reported a U-shaped association between sleep duration and depression defined by the PHQ-9 [22]. Less is known about how sleep duration and clinically reported sleep trouble combine, how their associations vary across population groups, and what proportion of the population burden of depressive symptoms they might account for — information that is directly relevant to prevention planning.

This study used nationally representative data from NHANES 2009–2012 to (i) describe the prevalence of a positive PHQ-2 depression screen by sleep duration and reported sleep trouble; (ii) estimate their independent and joint associations after adjustment for sociodemographic, behavioural and health factors; (iii) examine effect modification by sex, age and physical activity; and (iv) estimate predictive margins and population attributable fractions to inform prevention.

2. METHODOLOGY

2.1 Data Source and Participants

NHANES is a continuous, stratified, multistage probability survey of the civilian, non-institutionalised US population conducted by the National Center for Health Statistics (NCHS) [23], [24]. We used the 2009–2010 and 2011–2012 cycles as provided in the NHANESraw dataset of the NHANES package for R, version 2.1.4, which provides a pre-processed version of the 2009–2012 data (with recoded variables, including a merged top PHQ response category) together with the examination weights, strata

and primary sampling units [25]. We included adults aged ≥20 years, excluding those reporting current pregnancy, who answered both PHQ-2 items and both sleep questions, and had complete covariate data. The study is reported according to STROBE [26]. NHANES was approved by the NCHS Research Ethics Review Board and all participants gave written informed consent; this secondary analysis of de-identified public data required no further approval.

2.2 Outcome: Positive Depression Screen

The PHQ-2 comprises the first two items of the PHQ-9, which was administered in the mobile examination centre: depressed mood ("feeling down, depressed or hopeless") and anhedonia ("little interest or pleasure in doing things") over the previous two weeks, each scored from 0 (not at all) to 3 (nearly every day) [6]. A score ≥3 is the recommended screening threshold; in a large individual-participant meta-analysis it had a sensitivity of 0.72 and specificity of 0.85 for major depression [27]. In the dataset used, the two highest response categories ("more than half the days" and "nearly every day") are combined into a single category. We therefore scored that category as 2 in the main analysis, which yields a conservative classification (a participant classified as positive is positive under any original coding), and as 3 in a sensitivity analysis, which yields a liberal classification.

2.3 Exposures

Usual sleep duration on weekdays or workdays was self-reported in whole hours and grouped as ≤5, 6, 7 (reference), 8 and ≥9 hours, informed by consensus recommendations [16], [17]. For stratified and sensitivity analyses, predictive margins and attributable fractions, we used binary indicators of short sleep (≤6 hours) and long sleep (≥9 hours) relative to 7–8 hours. Sleep trouble was defined as having ever told a doctor or other health professional about trouble sleeping.

2.4 Covariates

Covariates were age group (20–39, 40–59, ≥60 years), sex, race and ethnicity, education, family income-to-poverty ratio (<1.30, 1.30–3.49, ≥3.50, with a missing category), marital status, employment status, survey cycle (Model 2), and smoking status, leisure-time physical activity, body mass index category and self-reported diabetes (Model 3). Model 1 adjusted for age and sex only.

2.5 Statistical Analysis

All analyses used combined four-year examination weights (one half of each two-year weight) and accounted for the 29 strata and 62 primary sampling units (33 degrees of freedom) [28]. Prevalences are presented with logit-transformed 95% confidence intervals (CIs) based on the t-distribution, with Taylor-series linearisation for variance. Logistic regression models were fitted by weighted maximum likelihood with design-based (linearisation) sandwich variance estimators [29], estimated within the complete-case subpopulation while retaining the full design. Sleep duration and sleep trouble were entered together in all models. Their joint association was examined with a ten-level combined variable, and multiplicative interaction was tested by adding duration × trouble product terms to Model 3 and applying a design-adjusted Wald F-test (4 and 30 degrees of freedom). Effect modification by sex, age group and physical activity was explored by stratified Model 3 analyses (excluding the stratifying variable); no formal test of heterogeneity across strata was performed.

Adjusted predictive margins were obtained by marginal standardisation over the observed covariate distribution [30]. Population attributable fractions were estimated as 1 − (predicted prevalence with the exposure set to its reference level ÷ observed predicted prevalence), which accounts for confounding [31], [32], [33], [34]. For short sleep, ≤6 hours was set to 7–8 hours with long sleep left as observed; for sleep trouble, all participants were set to no trouble. CIs for margins and PAFs were obtained with a stratified delete-one-PSU jackknife with within-stratum reweighting [35]. To gauge robustness to unmeasured confounding we computed E-values [36], treating ORs as approximate risk ratios because the outcome was uncommon (<10%). Sensitivity analyses used the liberal PHQ-2 coding, a lower PHQ-2 threshold of ≥2, frequent mental distress (≥14 poor mental health days in the previous 30) as an alternative

outcome, and restrictions to adults without diabetes and to adults aged 20–64 years. Analyses were performed in Python 3.11 with custom code using NumPy, pandas and SciPy (data read with pyreadr; figures drawn with Matplotlib).

3. RESULTS AND DISCCUSSION

3.1 Participants

Of 20,293 NHANES participants, 9,832 adults aged ≥20 years had valid PHQ-2 and sleep data (the descriptive sample, representing about 195 million US adults), and the 9,711 with complete covariates (about 193 million) formed the regression sample (Figure 1). Descriptive statistics refer to the 9,832 adults (Table 1). Mean usual sleep duration was 6.9 hours; 13.2% of adults slept ≤5 hours, 23.5% 6 hours, 29.3% 7 hours, 27.3% 8 hours and 6.7% ≥9 hours, and 26.8% had told a health professional about trouble sleeping.

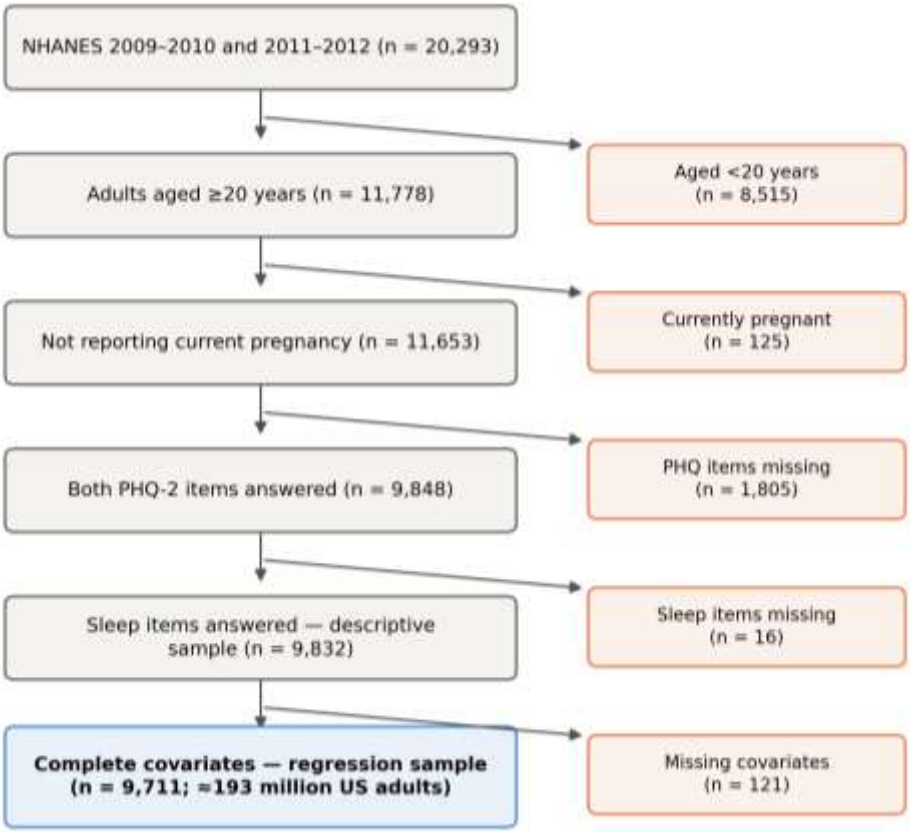

Figure 1. Selection of the Analytic Sample from NHANES 2009–2012

Overall, 6.8% (95% CI 6.0–7.7%) of adults had a positive PHQ-2 screen under the conservative coding, 9.3% (8.3–10.4%) under the liberal coding and 17.2% (15.7–18.8%) at a threshold of ≥2. Compared with adults who screened negative, those who screened positive were more often women (59.6% vs 49.6%), aged 40–59 years, living below 1.30 times the poverty line (42.2% vs 19.4%), not working, current smokers and physically inactive (Table 1). They slept less on average (6.5 vs 6.9 hours), more often slept ≤5 hours (28.2% vs 12.1%) or ≥9 hours (11.2% vs 6.4%), and were more than twice as likely to report sleep trouble (54.8% vs 24.8%).

Table 1. Characteristics of Adults Aged ≥20 Years by PHQ-2 Screening Status, NHANES 2009–2012 (n = 9,832)

Characteristic	All, %	PHQ-2 Negative (<3), %	PHQ-2 Positive (≥3), %
Unweighted n	9,832	9,006	826
Weighted % of adults	100	93.2	6.8

Age group, years			
20–39	35.1	35.5	29.5
40–59	38.5	37.6	50.7
≥60	26.4	26.8	19.9
Sex			
Women	50.3	49.6	59.6
Men	49.7	50.4	40.4
Race and ethnicity			
Non-Hispanic White	68.8	69.5	60.2
Non-Hispanic Black	10.9	10.6	15.6
Mexican American	7.8	7.8	8.3
Other Hispanic	5.6	5.3	9.7
Other/multiracial	6.7	6.8	6.2
Education			
< High school	17.0	16.1	29.3
High school	21.8	21.6	25.1
Some college	31.6	31.6	31.5
College graduate	29.6	30.7	14.1
Income-to-poverty ratio			
<1.30	20.9	19.4	42.2
1.30–3.49	33.4	33.4	33.5
≥3.50	39.4	41.0	18.4
Marital status			
Married/partner	62.3	63.5	45.8
Divorced/separated/widowed	18.8	18.1	28.8
Never married	18.9	18.4	25.4
Employment			
Working	61.9	63.5	41.2
Looking for work	3.7	3.7	5.1
Not working	34.3	32.9	53.7
Smoking			
Never	55.0	56.0	41.9
Former	25.0	25.2	22.6
Current	20.0	18.8	35.6
Leisure-time physical activity			
Active	54.1	55.6	33.2
Inactive	45.9	44.4	66.8
Body mass index, kg/m^2			
<25	30.4	30.7	26.5
25–29.9	33.6	33.9	29.7
≥30	36.1	35.5	43.8
Self-reported diabetes	11.2	10.8	17.8
Usual sleep duration			
≤5 h	13.2	12.1	28.2
6 h	23.5	23.5	23.6
7 h	29.3	30.2	16.7
8 h	27.3	27.8	20.3
≥9 h	6.7	6.4	11.2

Told health professional about trouble sleeping	26.8	24.8	54.8
Sleep duration, mean, hours	6.88	6.91	6.52

Survey-weighted percentages among participants with non-missing values, except income-to-poverty ratio, for which all participants form the denominator (6.3% missing, not shown). PHQ-2, two-item Patient Health Questionnaire.

3.2 Prevalence of a Positive Screen by Sleep Characteristics

The prevalence of a positive screen followed a U-shaped pattern across sleep duration, reaching its minimum at 7 hours (3.9%, 3.0–5.1%) and rising to 14.6% (12.5–17.0%) at ≤5 hours and 11.3% (8.5–14.9%) at ≥9 hours (Table 2; Figure 2a shows single hours). It was 13.9% (12.2–15.9%) among adults reporting sleep trouble and 4.2% (3.5–5.0%) among those not reporting it. Within every duration category, prevalence was higher with sleep trouble (2.4 to 4.3 times higher), ranging from 2.4% at 7 hours without trouble to 28.7% at ≥9 hours with trouble (Figure 2b).

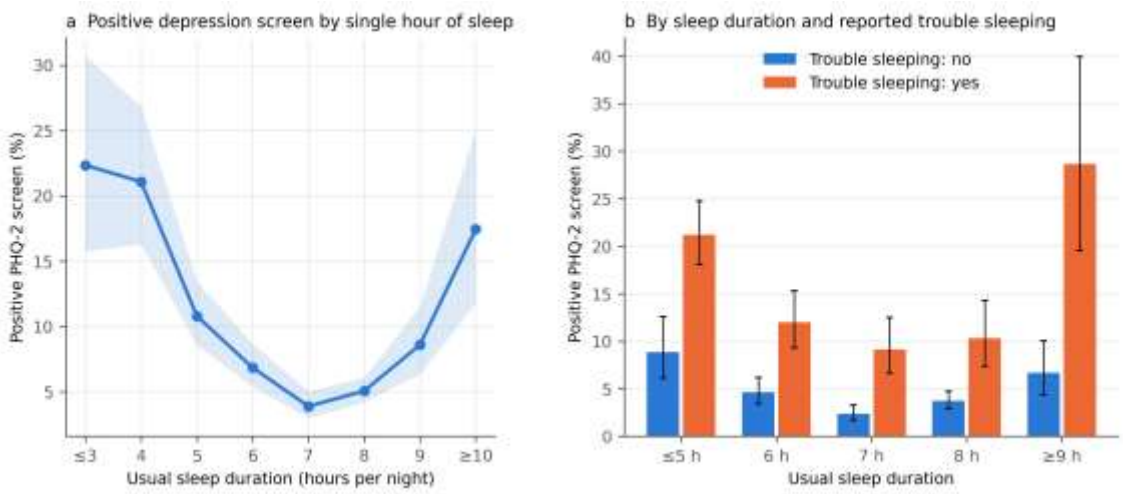

Figure 2. Weighted Prevalence of a Positive Depression Screen (PHQ-2 ≥3) (a) by Single Hour of Usual Sleep Duration (≤3 to ≥10 h) and (b) by Sleep Duration and Reported Sleep Trouble, with 95% Confidence Intervals

Table 2. Weighted Prevalence of a Positive Depression Screen (PHQ-2 ≥3) by Usual Sleep Duration and Reported Sleep Trouble

Sleep Characteristic	Unweighted n	All Adults, % (95% CI)	No Sleep Trouble, % (95% CI)	Sleep Trouble, % (95% CI)
≤5 h	1,550	14.6 (12.5–17.0)	8.9 (6.1–12.6) [n = 859]	21.2 (18.1–24.8) [n = 691]
6 h	2,352	6.8 (5.4–8.7)	4.6 (3.4–6.2) [n = 1,672]	12.0 (9.3–15.3) [n = 680]
7 h	2,583	3.9 (3.0–5.1)	2.4 (1.7–3.3) [n = 2,084]	9.1 (6.6–12.5) [n = 499]
8 h	2,613	5.1 (4.2–6.1)	3.7 (2.9–4.7) [n = 2,160]	10.3 (7.4–14.3) [n = 453]
≥9 h	734	11.3 (8.5–14.9)	6.7 (4.4–10.0) [n = 590]	28.7 (19.5–39.9) [n = 144]
All durations	9,832	6.8 (6.0–7.7)	4.2 (3.5–5.0) [n = 7,365]	13.9 (12.2–15.9) [n = 2,467]

Sleep trouble: ever told a doctor or other health professional about trouble sleeping. CI, confidence interval.

3.3 Adjusted Associations

Associations were attenuated by adjustment for sociodemographic factors but remained robust after further adjustment for health behaviours and conditions (Table 3, Figure 3). In the fully adjusted

model, sleeping ≤5 hours (OR 2.10, 95% CI 1.54–2.86) and ≥9 hours (OR 2.26, 1.48–3.45) were associated with a positive screen compared with 7 hours, while 6 hours (OR 1.37, 0.93–2.00) and 8 hours (OR 1.13, 0.74–1.73) were not significantly different. Reported sleep trouble was independently associated with roughly three-fold odds (OR 2.94, 2.35–3.68). Other independent correlates included income below 1.30 times the poverty line (OR 2.15), never having married (OR 1.92), not working (OR 1.84), physical inactivity (OR 1.76) and current smoking (OR 1.44). The E-values were 3.62 for ≤5 hours, 3.94 for ≥9 hours and 5.33 for sleep trouble, indicating that an unmeasured confounder would need to be associated with both the sleep characteristic and a positive screen by a risk ratio of at least 3.6–5.3 each, above and beyond the measured covariates, to explain the findings away.

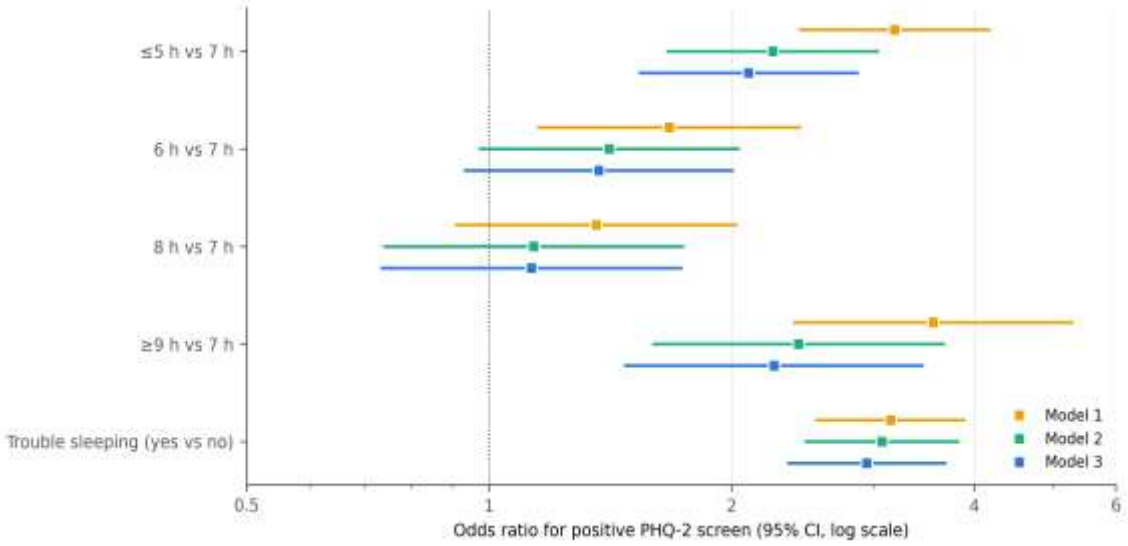

Figure 3. Odds Ratios (95% CI) for a Positive Depression Screen by Sleep Duration (Reference 7 h) and Sleep Trouble Across Three Levels of Adjustment (Log Scale)

Table 3. Adjusted Odds Ratios (95% CI) for a Positive Depression Screen (PHQ-2 ≥3) (n = 9,711)

Variable	Model 1 OR (95% CI)	Model 2 OR (95% CI)	Model 3 OR (95% CI)	Model 3 P
Sleep duration (vs 7 h)				
≤5 h	3.19 (2.43–4.17)	2.25 (1.67–3.04)	2.10 (1.54–2.86)	< 0.001
6 h	1.67 (1.15–2.43)	1.41 (0.97–2.04)	1.37 (0.93–2.00)	0.103
8 h	1.36 (0.91–2.03)	1.14 (0.74–1.74)	1.13 (0.74–1.73)	0.568
≥9 h	3.56 (2.39–5.29)	2.42 (1.60–3.67)	2.26 (1.48–3.45)	< 0.001
Sleep trouble (vs none)	3.15 (2.55–3.89)	3.07 (2.47–3.82)	2.94 (2.35–3.68)	< 0.001
Covariates (Model 3)				
Age 40–59 (vs 20–39)	1.36 (1.13–1.65)	1.76 (1.40–2.21)	1.57 (1.23–2.00)	< 0.001
Age ≥60 (vs 20–39)	0.73 (0.56–0.94)	0.69 (0.55–0.88)	0.62 (0.46–0.84)	0.003
Women (vs men)	1.31 (1.01–1.69)	1.20 (0.92–1.55)	1.20 (0.94–1.54)	0.139
Non-Hispanic Black (vs NH White)	—	1.10 (0.85–1.42)	1.06 (0.83–1.35)	0.628
Mexican American (vs NH White)	—	1.03 (0.76–1.38)	1.07 (0.79–1.44)	0.674
Other Hispanic (vs NH White)	—	1.79 (1.34–2.39)	1.85 (1.38–2.48)	< 0.001
Other/multiracial (vs NH White)	—	1.16 (0.79–1.69)	1.21 (0.83–1.76)	0.308
< High school (vs college graduate)	—	2.05 (1.34–3.14)	1.55 (0.99–2.42)	0.053

High school (vs college graduate)	—	1.56 (0.99–2.47)	1.28 (0.79–2.08)	0.303
Some college (vs college graduate)	—	1.42 (0.95–2.11)	1.23 (0.82–1.84)	0.303
Income-to-poverty <1.30 (vs ≥3.50)	—	2.46 (1.73–3.51)	2.15 (1.49–3.10)	< 0.001
Income-to-poverty 1.30–3.49 (vs ≥3.50)	—	1.61 (1.12–2.30)	1.48 (1.04–2.11)	0.030
Divorced/separated/widowed (vs married)	—	1.41 (1.17–1.71)	1.41 (1.18–1.69)	< 0.001
Never married (vs married)	—	1.82 (1.32–2.51)	1.92 (1.39–2.63)	< 0.001
Looking for work (vs working)	—	1.52 (0.94–2.45)	1.55 (0.98–2.45)	0.061
Not working (vs working)	—	1.90 (1.57–2.29)	1.84 (1.51–2.24)	< 0.001
Former smoker (vs never)	—	—	1.11 (0.85–1.45)	0.439
Current smoker (vs never)	—	—	1.44 (1.15–1.82)	0.003
Physically inactive (vs active)	—	—	1.76 (1.39–2.22)	< 0.001
BMI 25–29.9 (vs <25)	—	—	1.01 (0.75–1.36)	0.959
BMI ≥30 (vs <25)	—	—	1.10 (0.88–1.38)	0.382
Self-reported diabetes	—	—	1.29 (1.01–1.65)	0.042

Model 1: sleep duration, sleep trouble, age group and sex. Model 2: Model 1 plus race and ethnicity, education, income-to-poverty ratio (including a missing category), marital status, employment and survey cycle. Model 3: Model 2 plus smoking, physical activity, BMI and diabetes. Sleep duration and sleep trouble are mutually adjusted in all models. E-values (point estimate / lower confidence limit) for Model 3: ≤5 h 3.62 / 2.45; ≥9 h 3.94 / 2.32; sleep trouble 5.33 / 4.14. BMI, body mass index; NH, non-Hispanic; OR, odds ratio.

3.4 Joint Associations and Effect Modification

Compared with sleeping 7 hours without sleep trouble, the adjusted odds of a positive screen were highest for those combining an extreme duration with sleep trouble: OR 6.47 (4.03–10.39) for ≤5 hours with trouble and 10.48 (5.66–19.43) for ≥9 hours with trouble (Figure 4, Table 4). Sleep trouble was associated with higher odds at every duration, including 7 hours (OR 3.82, 2.40–6.08). The multiplicative interaction between duration and sleep trouble was not statistically significant (P = 0.17), although power to detect it was limited and the joint estimate for ≥9 hours with trouble exceeded the product of the separate associations.

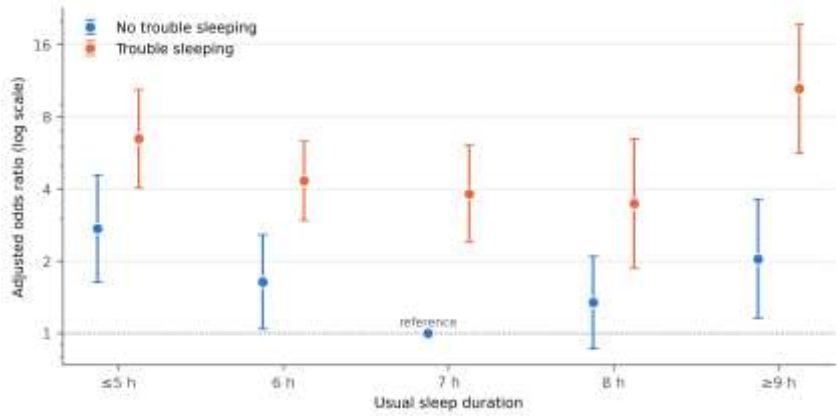

Figure 4. Joint Association of Sleep Duration and Sleep Trouble with a Positive Depression Screen (Model 3; Reference 7 h without Sleep Trouble; Log Scale)

Table 4. Joint Association of Sleep Duration and Sleep Trouble with a Positive Depression Screen (Model 3 Adjustment; Reference: 7 h without Sleep Trouble)

Sleep Duration	No Sleep Trouble: OR (95% CI)	Sleep Trouble: OR (95% CI)
≤5 h	2.73 (1.63–4.57)	6.47 (4.03–10.39)
6 h	1.63 (1.04–2.57)	4.32 (2.95–6.32)
7 h	1.00 (reference)	3.82 (2.40–6.08)
8 h	1.34 (0.86–2.09)	3.47 (1.87–6.45)
≥9 h	2.04 (1.15–3.60)	10.48 (5.66–19.43)

P for multiplicative interaction between sleep duration and sleep trouble (design-adjusted Wald F-test) = 0.17. OR, odds ratio.

The point estimate for short sleep (≤6 vs 7–8 hours) was largest in adults aged 40–59 years (OR 2.03, 1.55–2.65) and weaker and non-significant at 20–39 years (OR 1.14, 0.75–1.75) and ≥60 years (OR 1.36, 0.89–2.09); it was present in women (OR 1.66, 1.27–2.17) and of borderline significance in men (OR 1.38, 0.98–1.94) (Figure 6a, Table 5); no formal test of heterogeneity was performed. The association with sleep trouble was present in all subgroups, although weaker at ≥60 years (OR 1.98, 1.37–2.85) than at younger ages (ORs 3.50–3.82).

3.5 Predictive Margins and Attributable Fractions

After standardisation for all covariates, the predicted prevalence of a positive screen was 3.5% (2.9–4.1%) for adults sleeping 7–8 hours without sleep trouble, 5.3% with short sleep alone, 7.0% with long sleep alone, 9.5% with sleep trouble alone and 13.6% (11.4–15.8%) with both short sleep and sleep trouble (Figure 5a). Assuming the associations are causal, eliminating short sleep would reduce the prevalence of positive screens by 15.8% (10.2–21.5%), eliminating sleep trouble by 32.8% (26.2–39.5%), and eliminating both by 43.6% (36.8–50.3%) (Figure 5b).

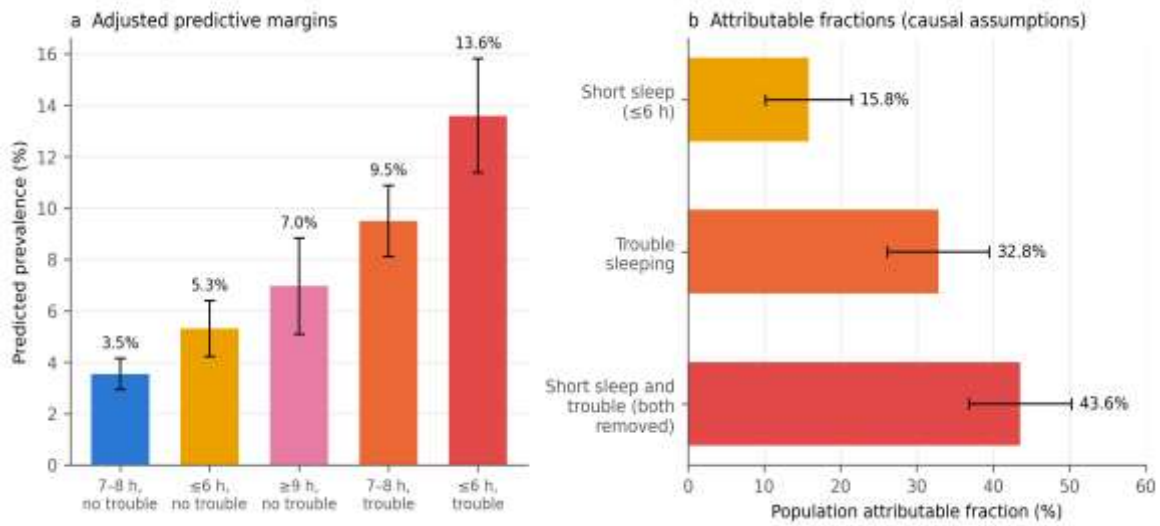

Figure 5. (a) Adjusted Predictive Margins of a Positive Screen by Sleep Profile and (b) Population Attributable Fractions for Short Sleep, Sleep Trouble and Both, with Jackknife 95% Confidence Intervals

3.6 Sensitivity Analyses

The associations were consistent across all sensitivity analyses (Figure 6b, Table 5). With the liberal PHQ-2 coding, ORs were 1.65 for short sleep, 2.20 for long sleep and 2.53 for sleep trouble. Associations persisted with a lower threshold (PHQ-2 ≥2), with frequent mental distress as the outcome, after excluding adults with diabetes and when restricted to adults aged 20–64 years.

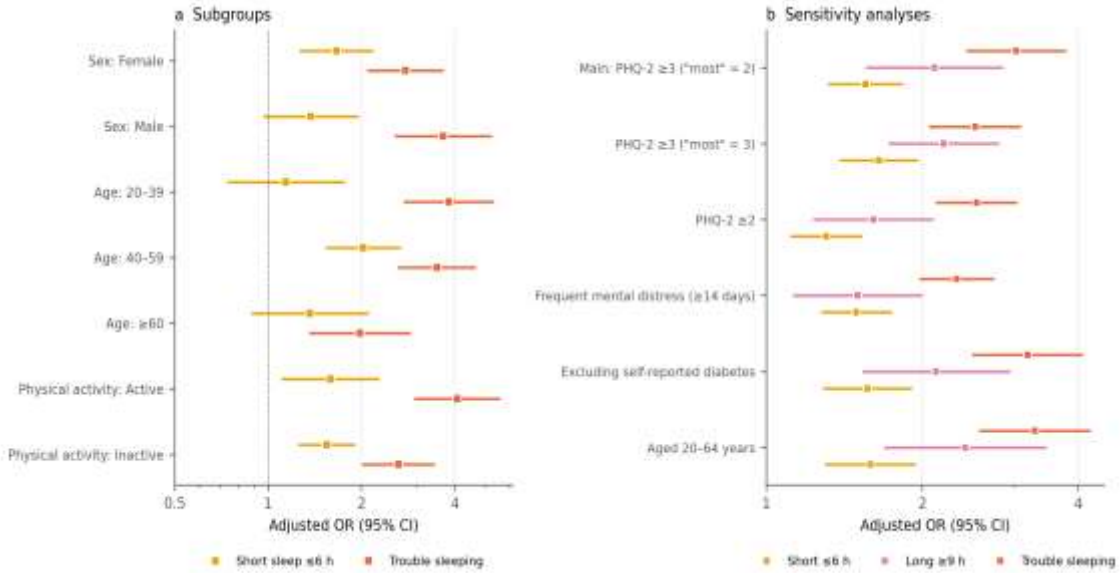

Figure 6. (a) Odds Ratios for Short Sleep and Sleep Trouble by Sex, Age Group and Physical Activity, and (b) Odds Ratios Across Sensitivity Analyses (Log Scale)

Table 5. Stratified and Sensitivity Analyses: Adjusted Odds Ratios (95% CI) for Short Sleep (≤6 h), Long Sleep (≥9 h) and Sleep Trouble

Analysis	N	Short Sleep ≤6 h vs 7–8 h	Long Sleep ≥9 h vs 7–8 h	Sleep Trouble
Stratified analyses (Model 3)				
Women	4,819	1.66 (1.27–2.17)	—	2.77 (2.10–3.64)
Men	4,892	1.38 (0.98–1.94)	—	3.67 (2.58–5.22)
Age 20–39 years	3,225	1.14 (0.75–1.75)	—	3.82 (2.75–5.29)
Age 40–59 years	3,244	2.03 (1.55–2.65)	—	3.50 (2.64–4.63)
Age ≥60 years	3,242	1.36 (0.89–2.09)	—	1.98 (1.37–2.85)
Physically active	4,652	1.59 (1.11–2.26)	—	4.07 (2.98–5.56)
Physically inactive	5,059	1.55 (1.26–1.90)	—	2.63 (2.02–3.42)
Sensitivity analyses				
Main analysis: PHQ-2 ≥3, conservative coding	9,711	1.56 (1.32–1.83)	2.11 (1.56–2.85)	3.04 (2.45–3.77)
PHQ-2 ≥3, liberal coding	9,711	1.65 (1.39–1.95)	2.20 (1.73–2.80)	2.53 (2.07–3.09)
PHQ-2 ≥2	9,711	1.31 (1.12–1.53)	1.61 (1.24–2.09)	2.55 (2.13–3.04)
Frequent mental distress (≥14 days) as outcome	9,698	1.49 (1.28–1.74)	1.50 (1.13–1.99)	2.33 (1.98–2.74)
Excluding self-reported diabetes	8,298	1.57 (1.29–1.90)	2.13 (1.54–2.95)	3.20 (2.51–4.07)
Restricted to ages 20–64 years	7,438	1.59 (1.30–1.93)	2.42 (1.70–3.46)	3.30 (2.59–4.21)

All models adjusted for Model 3 covariates (excluding the stratifying variable). Short and long sleep were entered as binary indicators with 7–8 h as reference. PHQ-2, two-item Patient Health Questionnaire.

3.7 Discussion

3.7.1 Principal Findings

In this nationally representative sample of US adults, both sleep duration and clinically reported sleep trouble were strongly and independently associated with a positive depression screen. The association with duration was U-shaped, with the lowest prevalence at 7 hours and about two-fold higher

adjusted odds at ≤5 and ≥9 hours. Sleep trouble was associated with about three-fold higher odds overall, and with higher odds within every duration category, and adults with both an extreme duration and sleep trouble had six- to ten-fold higher odds. Under causal assumptions, short sleep and sleep trouble together accounted for more than two-fifths of positive screens.

3.7.2 Comparison with Previous Studies

Our findings agree with prospective evidence. The two- to three-fold associations for sleep trouble resemble the pooled risk of incident depression associated with insomnia in meta-analyses (OR 2.60; RR 2.27) [9], [10]. The U-shaped pattern for duration is consistent with prospective meta-analysis (RR 1.31 for short and 1.42 for long sleep) [11] and with the NHANES 2009–2016 analysis using the PHQ-9 (OR 1.86 and 1.49) [22]. By modelling duration and sleep trouble jointly, our study shows that both remain associated with a positive screen after mutual adjustment, and that sleep trouble — which reflects a complaint serious enough to raise with a health professional — showed a stronger association than either short or long duration.

3.7.3 Interpretation

The cross-sectional design does not allow the direction of the association to be determined. Sleep disturbance is both a symptom and a predictor of depression, and the relationship is widely regarded as bidirectional [12], [13]. Long sleep may reflect depression-related fatigue, hypersomnia, physical illness or medication effects, whereas short sleep and insomnia may contribute to depression through hyperarousal, stress-system activation and impaired emotional regulation [13]. Apparent differences by age, which were not formally tested, may reflect differences in sleep need, work and caregiving patterns, or competing causes of short sleep. The attributable fractions should therefore be read as the maximum potential impact if the associations were causal and the exposures fully removable, not as established effects [34].

3.7.4 Implications for Prevention and Management

The findings support three practical steps. First, asking about sleep duration and sleep trouble in primary care and health checks takes little time and could help flag adults at elevated likelihood of depressive symptoms, complementing the universal PHQ screening recommended for adults [8]. Second, adults who report sleep trouble — more than a quarter of the population in our data — form a large group in which depressive symptoms are three times as common, and in which effective treatments exist: in randomised trials, CBT-I reduced depressive symptoms [14] and the incidence of major depression [15], and improving sleep improved broader mental health outcomes [37]. Third, population-level promotion of adequate sleep, consistent with consensus recommendations [17], should be considered as part of mental health promotion, with attention to the socioeconomic and racial disparities in sleep [19], [20].

3.7.5 Strengths and Limitations

Strengths include a large, nationally representative sample, a validated depression screening instrument, design-based estimation throughout, joint modelling of two sleep dimensions, and estimation of predictive margins and attributable fractions with design-based CIs.

There are limitations. First, the design is cross-sectional, so causality and its direction cannot be established, and the attributable fractions assume causality. Second, sleep duration was self-reported in whole hours for weekdays only, and sleep trouble was defined by having told a health professional, which depends on help-seeking and access to care. Third, the PHQ-2 is a screening instrument rather than a diagnostic interview, and the combined top response category required bounding the score; results were similar under both codings. Fourth, residual confounding is possible, for example by chronic pain, sleep apnoea, shift work, antidepressant or hypnotic use and other psychiatric conditions, none of which was available; the E-values suggest that only fairly strong confounding could fully explain the associations. Fifth, the data are from 2009–2012, and sleep and mental health patterns may have changed since, particularly after the COVID-19 pandemic. Sixth, the data were obtained from a pre-processed version of NHANES distributed in an R package whose documentation notes adaptation for educational use; although it retains

the survey design variables, replication with the original NCHS public-use files would be desirable. Finally, the logistic models were fitted to the complete-case subpopulation (98.8% of eligible adults).

4. CONCLUSION

Short and long sleep and clinically reported sleep trouble are strongly and independently associated with a positive depression screen in US adults, and adults with both an extreme sleep duration and sleep trouble have the highest likelihood of depressive symptoms. Asking about sleep is a simple way to flag adults at elevated likelihood of depressive symptoms alongside routine depression screening, and improving sleep — particularly through evidence-based treatment of insomnia — deserves evaluation as a strategy for the prevention and management of depression.

Author Contribution Statement

Name of Author	C	M	So	Va	Fo	I	R	D	O	E	Vi	Su	P	Fu
Dr. D. Victorseelan	✓	✓	✓		✓				✓		✓			✓
Dr. Satwik Chatterjee		✓	✓	✓		✓		✓		✓		✓		
Moldaliev Zhoomart	✓	✓	✓		✓		✓		✓		✓		✓	✓

C: **C**onceptualization
M : **M**ethodology
So : **So**ftware
Va : **Va**lidation
Fo : **Fo**rmal analysis
I : **I**nvestigation
R : **R**esources
D : **D**ata Curation
O : Writing - **O**riginal Draft
E : Writing - Review & **E**diting
Vi : **Vi**sualization
Su : **Su**pervision
P : **P**roject administration
Fu : **Fu**nding acquisition

Acknowledgments

The authors acknowledge the National Center for Health Statistics of the US Centers for Disease Control and Prevention for collecting and releasing the NHANES data, the NHANES participants, and the researchers whose works have been cited in this study.

Funding Information

This research has received no external funding.

Conflict of Interest Statement

No conflict of interest.

Informed Consent

Not Applicable. The study used only publicly available, anonymised data.

Ethical Approval

Not Applicable. The study is a secondary analysis of publicly available, anonymised data and involved no contact with human participants.

Data Availability

This study uses the publicly available NHANES 2009–2012 data of the National Center for Health Statistics, obtained from wwwn.cdc.gov/nchs/nhanes. No new datasets were created. The analysis code is available from the corresponding author on reasonable request.

Use of Generative AI

Generative AI tools were not used to generate the scientific content, data, analyses or results of this study. Any AI-assisted language editing was reviewed and revised by the authors, who take full responsibility for the content of this article.

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How to Cite: Dr. D. Victorseelan, Dr. Satwik Chatterjee, Moldaliev Zhoomart. (2026). Sleep duration, sleep complaints and positive depression screening in US adults: dose–response and population attributable fractions from NHANES 2009–2012. Journal of Prevention, Diagnosis and Management of Human Diseases (JPDMHD), 6(2), 18-32. https://doi.org/10.55529/jpdmhd.62.18.32

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